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The status of the whip spider subgenus *Neocharon* (Amblypygi: Charontidae) and the distribution of the genera *Charon* and *Stygophrynus*

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Abstract. The Solomon Island endemic species of Charontidae, *Stygophrynus (Neocharon) forsteri* Dunn 1949, is transferred to the genus *Charon*, thus forming the new combination *Charon forsteri* (Dunn 1949). The subgenus *Neocharon* is a junior synonym of *Charon*. The distribution of *Stygophrynus* is found to be restricted to Southeast Asia from southern Myanmar to Java, not spreading east of Wallace's Line. We provide a full description, diagnosis, and numerous figures of *Charon forsteri*.

Keywords: Taxonomy, new combination, new synonymy, redescription, Wallace's Line, Australasia, Sundaland

Amblypygi, commonly known as whip spiders, are peculiar arachnids characterized by strong raptorial palps with sharp spines, a flattened body, and extremely elongate antenniform first legs. They are nocturnal and live under stones or on trees, and many are found in caves. Globally more than 158 whip spider species occurring in tropics and subtropics are currently recognized; they are classified into 17 genera of the five families (Harvey 2007; Rahmadi & Harvey 2008; Colmenares-Gareía & Villareal-Manzanilla 2008; Rahmadi et al. 2010; Rahmadi & Kojima 2010).

Of these five families, the dominant Asian family is the Charontidae, which consists of two genera, *Charon* Karsch 1879 and *Stygophrynus* Kraepelin 1895. *Charon* consists of four species distributed in Southeast Asia and Australasia (Harvey & West 1998; Harvey 2003), whereas *Stygophrynus* currently consists of nine species (Weygoldt 2002; Harvey 2003; Rahmadi & Harvey 2008) distributed in Southeast Asia and the southwestern Pacific (Harvey 2003). *Stygophrynus* is further divided into two subgenera, *S. (Stygophrynus)* for seven species from Myanmar, Thailand, Vietnam, Malay Peninsula to Java: *S. (S.) cavernicola* (Thorell 1889), *S. (S.) cerberus* Simon 1901, *S. (S.) berkeleyi* Gravely 1915, *S. (S.) longispina* Gravely 1915, *S. (S.) dammermani* Roewer 1928, *S. (S.) brevispina* Weygoldt 2002 and *S. (S.) sunda* Rahmadi & Harvey 2008, and *S. (Neocharon)* Dunn 1949 for *S. (N.) moultoni* Gravely 1915 and *S. (N.) forsteri* Dunn 1949. The two *Neocharon* species show unusually disjunct distribution pattern with *S. (N.) moultoni* known only from western Borneo (Quintero 1986; Harvey 2003; Rahmadi & Harvey 2008) and the type species, *S. (N.) forsteri* from the Solomon Islands (Dunn 1949; Harvey 2003).

In the present study, we examined the morphological characters of Charontidae mainly to clarify the identity of *S. (Neocharon) forsteri*, which is found far to the east of the remaining species of *Stygophrynus* and is thus a biogeographic enigma.

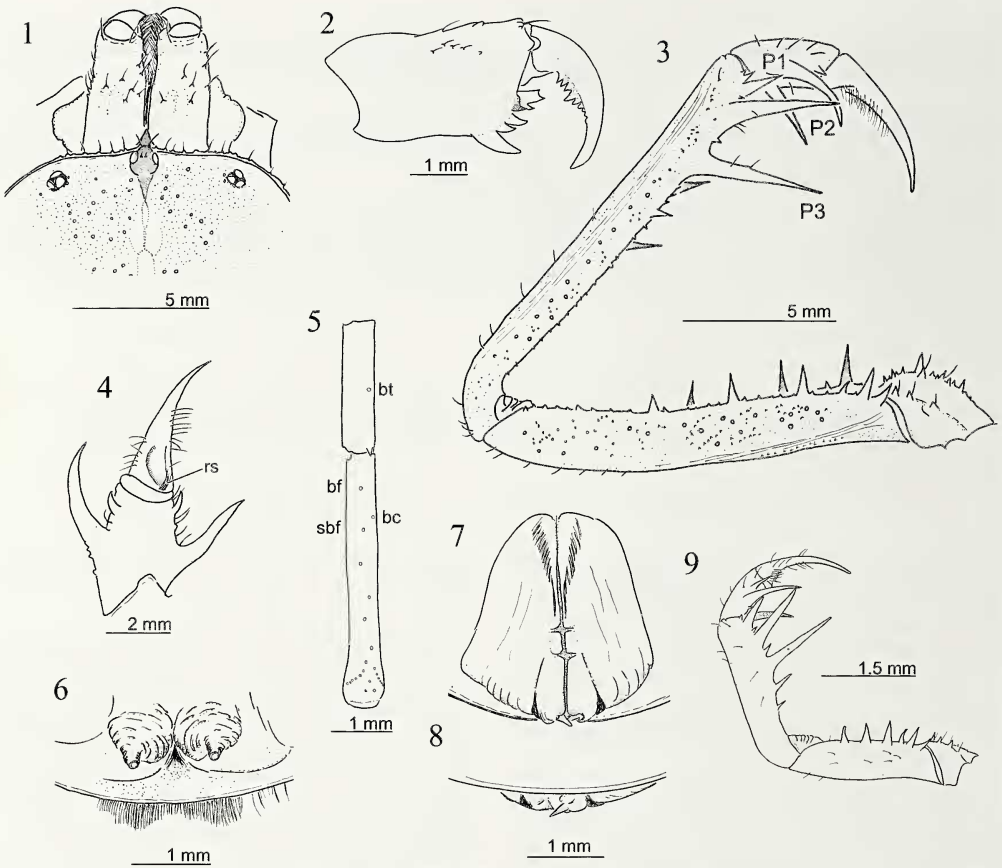
METHODS

The measurements and drawings were made using, respectively, an ocular micrometer and a drawing tube mounted on a stereoscopic dissecting microscope (Olympus SZX12). We examined the structure of the genitalia by lifting the genital operculum. General terminology and pedipalp spination follow Weygoldt (2000), and the pedipalp terminology follows Harvey & West (1998). The holotype and the specimens examined during the study are deposited in the following institutions: Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand (NMNZ); Queensland Museum, Brisbane, Australia (QM); Australian Museum, Sydney, Australia (AM); and Zoological Museum, University of Copenhagen, Copenhagen, Denmark (ZMUC).

THE IDENTITY OF *STYGOPHRYNUS (NEOCHARON) FORSTERI*

Dunn (1949) described *S. (Neocharon) forsteri* from Savo Island, in the Solomon Islands and proposed the subgenus *Neocharon* to accommodate *S. moultoni* and *S. forsteri*, with the latter designated as the type species. Weygoldt (2002) assumed that *Stygophrynus (N.) forsteri* was likely to be based on immature specimens as the size was relatively small for the genus.

Digital images supplied to us of the holotype of *S. forsteri*, housed in the Museum of New Zealand Te Papa Tongarewa (Wellington, New Zealand) (Figs. 10–12), show that the specimen has a spine P1 on the dorsal pedipalpal patella much shorter than the two other major spines (P2 and P3), which are about equal in size (Figs. 9, 11). The pedipalpal tibia has a single major spine on the dorsal and ventral



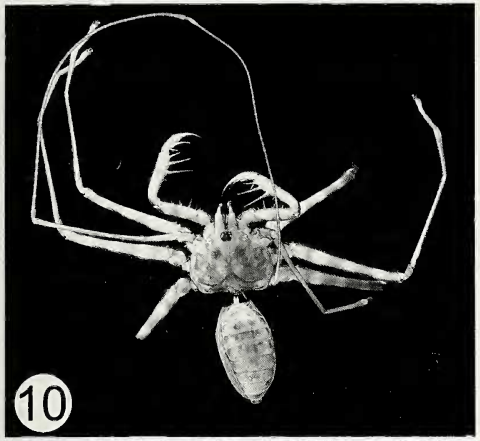
Figures 1–9.—*Charon forsteri* (Dunn 1949), from the Solomon Islands: 1. Carapace; 2. Chelicera, external view (AM, KS109147); 3. Antero-dorsal of left pedipalp (AM, KS109139); 4. left pedipalpal tibia, retro-lateral (ZMUC.01); 5. Tibia of leg IV (AM, KS109139); 6. Female genitalia, ventral view; 7. Male genitalia, dorsal view (ZMUC.02); 8. Male genitalia, ventral view; 9. Left pedipalp of immature specimen from New Georgia Island (QM, S42991), dorsal view. Abbreviations: rs: row of setae, bt: basitibial, bf: basofrontal, bc: basocaudal, sbf: subbasofrontal.

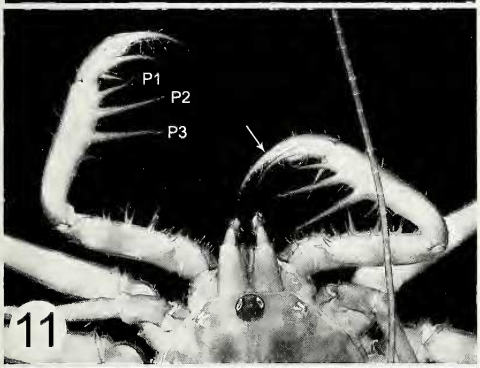
surfaces, with one additional spinelet on the distal region of the major spine, and an undivided pedipalpal tarsus (Fig. 12). The subgenus *Neocharon* differs from the subgenus *Stygophrynus* in having a lower number of spinelets on the distal of major spines on the pedipalpal tibia, particularly on the ventral margin. The subgenus *Stygophrynus* has at least three spinelets on both the dorsal and ventral margin, decreasing in size from distal to proximal, and *Neocharon* has only one spinelet (Dunn 1949; compare with Kraepelin 1895; Weygoldt 2002). All of these characteristics suggest that the holotype of *S. forsteri* is an immature individual of a species of *Charon* (Rahmadi 2009). As we will later show, it is different from any *Charon* species so far described, and we propose here to transfer *S. forsteri* to *Charon* as a valid species. Subsequently, *Neocharon* Dunn 1949, of which the type species is *S. forsteri*, is synonymized under *Charon*.

TAXONOMY

Family Charontidae Simon 1892

Diagnosis.—Family Charontidae is characterized by the presence of pulvilli on the second to fourth legs, dorsal margin of the pedipalpal patella with two (Fig. 3) or three major spines about equal in size in adults, the presence of a row of setae on the proximal end of the cleaning organ (Fig. 4), and also by the soft and tube-like gonopods of the





Figures 10–12.—Holotype of *Charon forsteri* (Dunn 1949): 10. Habitus, dorsal view; 11. Carapace and pedipalp, dorsal view; 12. Ventral view. Photo by Jean-Claude Stahl/Museum of New Zealand Te Papa Tongarewa. The image of the holotype can also be found online at http://collections.tepapa.govt.nz/objectdetails.aspx?oid=127888&term=Stygophrynus.

female genitalia (Fig. 6) (Quintero 1986; Harvey & West 1998; Weygoldt 2000, 2002).

Remarks.—The family Charontidae contains two genera, *Charon* and *Stygophrynus*, which are united by a single synapomorphic character: the presence of a row of setae on the proximal end of the cleaning organ on the pedipalpal tarsus (Quintero 1986; Weygoldt 1996, 2000). They are distinguished from each other by the states of the pedipalp (Quintero 1986; Harvey & West 1998; Weygoldt 2000), where the tarsus is divided in *Stygophrynus* and undivided in *Charon*; an undivided tarsus is considered apomorphic in Charontidae (Quintero 1986; Weygoldt 1996, 2000), supporting the monophyly of *Charon.* The pedipalpal patella of *Charon* has two major spines (P2 and P3) about equal-sized and much longer than distal (P1) and proximal (P4) ones. In immature individuals, it has three long spines (P1–P3), of which the distal one (P1) is somewhat shorter than the others, while that of *Stygophrynus* has three equal-sized major spines (P1–P3) in both adult and immature individuals. It is assumed that the two equal spines in *Charon* is apomorphic compared to three equal spines in *Stygophrynus* in the family Charontidae (Weygoldt 1996), suggesting that the equal-sized two or more spines is the apomorphic condition in Neoamblypygi. The pedipalpal tibia of *Stygophrynus* has at least three spinelets distal to the major spine both dorsally and ventrally, whereas *Charon* has only a single spinelet distal to the major spine (Fig. 4). In *Stygophrynus,* the pedipalpal tarsus carries up to eight denticles, which is apomorphic in Charontidae and seems to support the monophyly of *Stygophrynus* (Weygoldt 1996). *Charon* has no such denticles on the pedipalpal tarsus (Fig. 4).

Genus *Charon* Karsch 1879

Charon Karsch 1879:197; Harvey 2003:9 (full synonymy).
Stygophrynus (Neocharon) Dunn 1949:11. **New synonymy.**

Type species.—*Charon: Phrynus grayi* Gervais 1842, by original designation.

Stygophrynus (Neocharon): Stygophrynus (Neocharon) forsteri Dunn 1949, by original designation.

Remarks.—The proposed synonymy of *Stygophrynus (Neocharon)* with *Charon* does not involve the transfer of *S. moultoni* to *Charon.* The identity of *S. moultoni* is still uncertain (Rahmadi et al. 2010), although it is tentatively treated as belonging to *Stygophrynus.*

Charon forsteri (Dunn 1949), comb. nov.
(Figs. 1–12)

Charon grayi (Gervais 1842): Pocock 1898:458; Rainbow 1913:2 (misidentification).
Stygophrynus (Neocharon) forsteri Dunn 1949:12–15, figs. 4–6; Palma et al. 1989:19; Weygoldt 2002:135; Harvey 2003:10; Rahmadi & Harvey 2008:281–288; Rahmadi 2009:117.

Type.—Holotype female, Savo Island, Solomon Islands [9.1392°S, 159.8131°E], January 1944, R.R. Forster, (NMNZ, image examined).

Other material examined.—SOLOMON ISLANDS: 1 ♂, 1 ♀, rainforest 17 km of Honiara [9.4485°S, 159.9456°E, approx.], Guadalcanal, 29 July 1962, Noona Dan Expedition 1961–62 (ZMUC); 1 ♀, Solomon Islands, mid 1966, D. Joddelf (AM KS83733); 1 ♀, Gout Station, Santa Isabel [7.9013°S,

159.1442°E, approx.], N.S. Hefferman (AM KS109147); 1 ♀, Gout Station, Santa Isabel [7.9013°S, 159.1442° E, approx.], N.S. Hefferman (AM KS109139); 1 ♀, Mt. Javae, Howla Island [8.2305°S, 157.5851°E, approx.], LK30244, New Georgia Island, 300 m, 25 June 1990, T. Churchill (QM S42991).

Diagnosis.—*Charon forsteri* can be distinguished from other congeners by the following combination of characters: basitibiae of legs II–III with 1 segment; basitibia of leg IV with 4 segments, with trichobothrium *bt* midway on fourth basitibial segment; and distitibiae with 25 trichobothria, trichobothrium *bc* closer to *sbf* than to *bf* (Fig. 5).

Description.—*Female:* Color in alcohol: carapace brown; pedipalpal trochanter, femur, patella and tibia dark brown; femur and patella of leg I brown without white annulations; tibia and tarsal segments of leg I with yellow annulations on each segment; legs II–IV: femora pale brown with annulations, 4 brown and 3 white annulations, patellae brown; basitibiae brown without annulations. Abdomen reddish brown.

Carapace (Fig. 1): Width about 1.6 times length. Surface with small tubercles and several setiferous tubercles, central sulcus deep, on midline about one fourth of the posterior part of carapace with 3 pairs of radiating sulci; flange narrow and slightly bent upwards on lateral and posterior margins; flange begins from antero-lateral corner; anterior margin straight with 12 fine frontal setae; median eye tubercle high and brownish-black with 2 apical setae, eyes facing antero-laterally; lateral eyes close to lateral margin about the diameter of lateral eyes; lateral eyes with normal pigmentation and with tapetum, arranged in line with median eyes; frontal process visible on dorsal view (Fig. 1).

Chelicera (Figs. 1, 2): Dorsum of chelicera with several tubercles, with 2 fine frontal setae on anterior margin and several fine setae on lateral margin (Fig. 1). Basal segment with 4 median teeth, the proximal tooth largest, the most distal tooth tricuspid of which the medial cusp is the largest, upper cusp larger than lower cusp; externally with one tooth opposite the uppermost tricuspid tooth; movable finger with 9 teeth, the fourth tooth the largest, following teeth decreasing in size distally (Fig. 2).

Sternum: First sternite (= tritosternum) elongate, with paired apical and several other setae; second and third sternites rounded and each with 2 apical setae; fourth sternite with 5–10 setae.

Pedipalp (Figs. 3, 4): Pedipalp short and stout. Trochanter with about 14 spines on antero-dorsal margin, with basal setae and several setiferous tubercles; antero-ventral margin with 13 spines containing basal setae. Femur: antero-dorsal margin with 5 major spines (length F3 > F2 > F4 > F1 > F5) and several minor spines (Fig. 3); antero-ventral margin with 4 major spines (length FII > FIII > FI > FIV), several minor spines and small tubercles. Patella: antero-dorsal margin with 4 major spines (length P2 = P3 > P1 > P4), spine P1 reduced in size, and with several minor spines, the two equal major spines located on distal one-fourth of patella, 2 minor spines present between P1 and distal margin of patella, P1 about half the length of P2, 1 minor spine present between P1–P2 and P2–P3; antero-ventral margin with 4 major spines (length PI > PII > PIII > PIV), several minor spines and small tubercles (Fig. 3). Tibia: antero-dorsal margin with 1 major spine plus 1 short spine distal to major spine; antero-ventral margin with 1 major spine plus 1 spine distal to major spine (Fig. 4). Tarsus undivided and without articulation, antero-dorsal margin without denticles dorsal to cleaning organ, with basal row of setae (rs) consisting of about 5 setae near proximal end of cleaning organ; cleaning organ ventrally with about 27 modified hairs.

Legs (Fig. 5): Femora of legs I–IV with small tubercles and setiferous tubercles. Tibia and tarsus of leg I with 25 and 45 segments, respectively; tibiae of legs II and III two-segmented; basitibiae of leg IV four-segmented, fourth basitibial segment with 1 trichobothrium (value in parentheses: ratio of the distance from trichobothrium to proximal margin of the segment against the length of the segment), bt (0.52); distitibiae of legs II–IV each with 24 trichobothria, bf (0.14), sbf (0.30), bc (0.26), bt about midway of fourth basitibial segment, bc close to sbf (Fig. 5). Tarsi of legs II–IV four-segmented; first segment about as long as length of subsequent three segments combined; second segment with light-yellow transverse line; fourth segment without oblique slit; pulvilli present.

Genitalia (Fig. 6): Gonopods soft and tube-like, with setae on margin of genital operculum (Fig. 6).

Male: Pedipalp spination similar to female, pedipalp short and stout. Genitalia: covered ventrally by genital operculum, without fine setae, posteriorly with paired pointed ventral lobes, paired brown markings on basal of ventral lobes (Fig. 8), in dorsal view, submedian yellow marking running from anterior margin to middle. In median part with paired rectangular lamellar (Fig. 7).

Juvenile: Color in alcohol: carapace light yellow with light brown marking, legs with annulations (Fig. 10). Carapace: anterior margin straight with several fine setae. Median eye tubercle well developed, eyes facing antero-laterally. Lateral eyes well developed (Fig. 11). Pedipalp: short and stout (Figs. 9–11). Femur: antero-dorsal margin with 6 major spines (length F2 > F5 > F4 > F3 > F1 > F6). Patella: antero-dorsal margin with 4 major spines (length P2 = P3 > P1 > P4). Tibia: antero-dorsal and ventral margins each with 1 major spine and with additional short spine at base of major spines on dorsal major spines and 1 spine on distal of major spine. Tarsus undivided (Fig. 12).

Measurements (in mm): adult male (n = 1) [females (n = 6)], juvenile (n = 1); values for segments of appendages are their lengths. Body length (excluding chelicera) 18.50 [17.20–28.00], 7.00. Carapace: median length 5.50 [6.00–10.00], 2.80; width 9.50 [9.76–16.00], 4.00; median eyes to anterior margin of carapace 0.20 [0.16–0.20], 0.00; distance between lateral eyes 3.50 [3.60–7.00], 1.36; lateral eye to anterior margin of carapace 0.50 [0.48–0.70], 0.20; lateral eye to lateral margin of carapace 0.60 [0.48–0.70], 0.20. Pedipalps: trochanter 3.00 [3.20–6.00], 1.00; femur 10.00 [11.20–23.50], 2.60; patella 11.50 [12.00–27.00], 2.60; tibia 2.50 [3.20–5.40], 1.04; tarsus 2.50 [3.20–7.50], 1.60. Leg I: femur 17.00 [17.60–32.50], 8.00; patella 1.20 [1.20], 0.60. Leg II: femur 11.00 [11.20–20.00], 5.00; patella 2.00 [1.76–3.00], 0.80; basitibia 10.50 [10.40–21.00], 4.60; distitibia 4.50 [4.40–8.00], 2.40; metatarsus + tarsus 3.80 [3.84–6.00], 1.80. Leg III: femur 11.50 [12.40–22.50], 5.72; patella 2.00 [1.76–3.00], 0.80; basitibia 11.50 [12.90–18.50], 5.40; distitibia 4.50 [4.80–6.50], 2.72; metatarsus

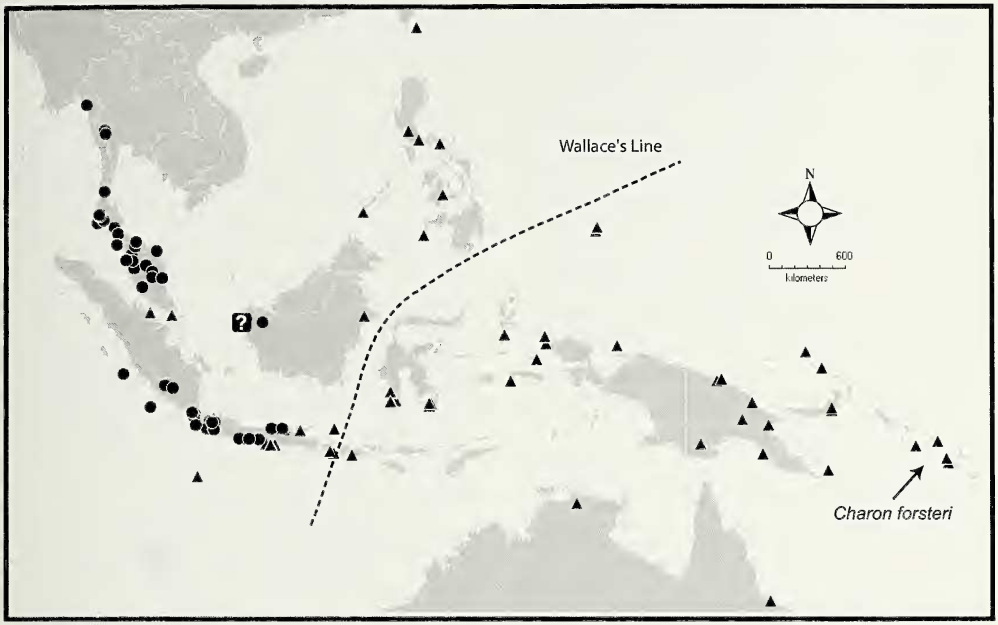


Figure 13.—Map showing the distribution of *Stygophrynus* and *Charon* (Charontidae) in Australasia. Symbols: circles: *Stygophrynus*; triangles: *Charon*. The dashed line depicts Wallace's Line.

+ tarsus 4.00 [3.60–5.84], 2.20. Leg IV: femur 10.50 [11.20–19.50], 5.20; patella 1.50 [1.60–3.00], 0.80; basitibia 12.00 [13.20–24.00], 5.60; distitibia 4.50 [4.40–7.00], 2.40; metatarsus + tarsus 4.00 [3.84–6.40], 2.20.

Etymology.—The species was named in honor of R.R. Forster, who facilitated the examination of the whip spider specimens in the Dominion Museum (Dunn 1949). He went on to become Director of the Otago Museum and a world authority on spiders (Patrick et al. 2000).

Natural history.—The specimens from Savo Island were found under debris in coastal forest and a coconut plantation (Dunn 1949). At a place about 17 km from Honiara in Guadalcanal, the species lives in rainforest.

Distribution.—This species is known from Savo Island, Santa Isabel, New Georgia, and Guadalcanal, all within the Solomon Islands (Fig. 13).

Remarks.—*Charon forsteri* was initially described by Dunn (1949) based on three immature female specimens with the total length of the holotype about 6.8 mm. In adults, the total length varies between 17.2–28.0 mm. The holotype has an additional basal major spine on the antero-dorsal margin of the pedipalpal tibia (Figs. 9, 11; Dunn 1949:12, fig. 6), but this spine is missing in adults (Fig. 4).

The pedipalpal patella of the holotype has three major spines, of which P1 is only shorter than the other two spines (Figs. 9, 11). This arrangement is typical of the immature individuals of the genus *Charon*. Weygoldt (1996, 2000) reported that in *Charon* the major spine P1 reduces in length during the post-embryonic development, and only the two major spines remain long in the adult stage (Fig. 3; also see Weygoldt 2000, fig. 26). One spine is present between P1 and distal margin of pedipalpal patella, instead of two or three spines that are commonly found in the genus *Stygophrynus*.

Charon forsteri differs from other *Charon* species in the number and arrangement of the trichobothria on the tibia of leg IV. *Charon forsteri* has 25 trichobothria on the tibia of leg IV with trichobothrium *bt* mid-length on the fourth basitibial segment of leg IV and the trichobothrium *bc* close to *sbf* (Fig. 5). The number and arrangement of the trichobothria on the tibia of leg IV in *Charon* are species-specific, which was found in the species described by Harvey & West (1998) from northern Australia and Christmas Island. Specimens from New Guinea, Philippines and the Indonesian islands also have different numbers and arrangements of trichobothria in each population, confirming that trichobothria are important diagnostic characters in the genus *Charon*. Kraepelin (1895, 1899) synonymized several species with *C. grayi* and recorded it from a variety of locations. Our observations suggest that species-specific characters are available to refute this hypothesis, and in future it will be necessary to recognize more species of *Charon* than are currently recognized. The Solomon Islands was amongst the many locations recorded by Kraepelin (1895, 1899) for *C. grayi*. It was likewise recorded from New Georgia by Pocock (1898) and Howla

Island by Rainbow (1913). We can find no evidence that *C. grayi* occurs in the Solomon Islands, and all previous records of *Charon* are here thought to represent *C. forsteri*.

DISTRIBUTION OF THE GENUS *STYGOPHRYNUS*

The transfer of *S. forsteri* from *Stygophrynus* to the genus *Charon* allows us to comment on the distribution of *Stygophrynus*. *Stygophrynus* has been recorded from various localities including Myanmar (Thorell 1889; Annandale & Gravely 1914), Thailand (Deharveng & Leclerc 1989; Weygoldt 2002), Vietnam (Kraepelin 1901), Engano Island (Delle Cave 1986), Mentawai Island (Annandale & Gravely 1914; Gravely 1915), Malay Peninsula (Gravely 1915), Java (Gravely 1915; Roewer 1928; Rahmadi & Harvey 2008), Borneo (Gravely 1915) and Sulawesi (Whitten et al. 2001). The record of the genus in Mampu Cave, Sulawesi (Leefmans 1932; Whitten et al. 2002, fig. 8.9) appears to be incorrect, as the figure resembles a species typical of the genus *Charon*. Extensive collections of whip spiders from Sulawesi, Moluccas, and eastward to the Papuan region confirm the absence of the genus *Stygophrynus* in these regions (Fig. 13).

Kraepelin (1901) and Harvey (2003) reported *S. cavernicola* from Saigon (Ho Chi Minh, Vietnam) but this record has been questioned (Annandale & Gravely 1914; Gravely 1915). After examining Kraepelin's specimen from Saigon lodged in MNHN labeled "BOC14, *Stygophrynus cavernicola*, Saigon Harmand 2327-75, Kraepelin det. 1900," we confirm that the specimen is a typical member of the genus *Phrynichus* (Phrynichidae). Weygoldt (1998) described the new species *Phrynichus orientalis* Weygoldt 1998 based on five specimens from Indochina previously identified as *Myodalis (Phrynichus) nigrimanus* (Koch) (MNHN82, MNHN81). One of these specimens was collected from Saigon (M. Harmand) and is also labeled with the number 2327-75 and identified as *Phrynichus reniformis* Kraepelin det. 1900. The specimen identified as *S. cavernicola* from Saigon lacks any label indicating *Phrynichus orientalis, P. nigrimanus,* or *P. reniformis.* The jar (BOC14) is together with other jars containing *Stygophrynus* species. Whether or not the specimens described by Weygoldt (1998) in MNHN represent the same specimen, we can be certain that Kraepelin's record of *Stygophrynus* from Vietnam is incorrect.

Based on the examination of numerous charontid specimens from several localities, we conclude that the genus *Stygophrynus* is restricted to southeastern Asia from southern Myanmar to northeastern Java and only occurs west of Wallace's Line (Fig. 13), both in caves and epigean habitats where extensive radiations have occurred (Weygoldt 1996). The sole record of *Stygophrynus* from western Borneo is dubious and requires further taxonomic examination (Rahmadi et al. 2010). The genus *Charon* is more widely distributed and occurs from northern Australia, New Guinea westward to Philippines, Sulawesi, Orchid Island in Taiwan, and north-eastern Java (Fig. 13). The distribution ranges of the two genera only overlap in a narrow area in the southern part of Sunda Land.

A biogeographic scenario proposed by Weygoldt (2000) stated that Neoamblypygi (Charontidae + Phrynida (Phrynichidae + Phrynidae)) evolved in Gondwanaland before Gondawana broke up during the Cretaceous period, and divided early into the Oriental Charontidae (*Charon* and *Stygophrynus*) and more western Phrynida. However, the split of Charontidae into two genera, Asian genus *Stygophrynus* and Australian genus *Charon* remains to be tested.

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